Guide to Good Industry Practices

Reticulated LPG Systems

WLPGA

LPG
EXCEPTIONAL
ENERGY

CONTENTS

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1.0 BACKGROUND

The WLPGA is committed to providing independent advice to LPG stakeholders to ensure safety in the operation of LPG equipment. The two WLPGA publications – *Guidelines for Good Business Practices* and *Guidelines for Good Safety Practices* - have been used extensively during the last two decades, all over the world, to provide guidance across key areas of the LPG industry.

These two Guidelines have been designed to provide general advice to all stakeholders on good industry practices throughout the supply and distribution chain.

Following the success of these Guidelines it was decided to develop and publish more detailed advice in certain areas of the LPG business that are considered more critical and where more prescriptive advice would be helpful.

The first of these was the *Guide to Good Industry Practices for LPG Cylinder Management,* which addressed the life cycle of an LPG cylinder from acquisition through to disposal. Others Guides that followed included various topics including *Guide to Good Industry Practices for LPG Cylinder Filling* and *Guide to Good Industry Practices for LPG Cylinders in the Distribution Channel.* (https://www.wlpga.org/publications/good-industry-practices/)

This latest *Guide to Good Industry Practices for LPG Reticulated Systems* examines all aspects of supplying LPG through a reticulated, or piped, metered supply.

Almost 50% of the total global demand for LPG is consumed in the domestic sector where it is used as a primary fuel for cooking, hot water, and space heating. Most of this is supplied individually with cylinders but there are examples where some domestic consumers - and commercial and industrial ones - are supplied through a piped network, eliminating the need for investment in cylinders.

This Guide focuses on describing aspects of developing a reticulated LPG system including some definitions, planning, constructing and maintenance. The Guide also includes sections on safety and how to deal with emergencies if they occur.

It is recommended that this Guide be read in conjunction with the other Guides in the series especially the *Guide to Consumer Safety* and the *Guide to Bulk LPG Systems*.

The information provided here should be applied in conjunction with any local laws or regulations to enhance the overall safety performance of the LPG business.

This document is a guide and not a standard. This guide does not supersede any code, standard or regulation that has been adopted by any country or local jurisdiction. However, the information in this guide may be useful to individual countries or companies where such codes, standards or regulations do not already exist. In those cases, consideration may be given to making some of this advice mandatory.

2.0 OBJECTIVES OF THE GUIDE

The objectives of this guide are to explain the concept of using a reticulated or piped system to deliver LPG to consumers and to illustrate the benefits of doing so.

Most of the LPG delivered to the key traditional sectors - domestic, commercial, and industrial – is done so using cylinders. Cylinders are a safe, versatile option but there are disadvantages in using them.

The use of cylinders is a convenient option for consumers who are scattered and where consumption is low. Where there are clusters of consumers, especially with high demand patterns, the use of providing supplies through cylinder banks, or a small bulk tank, are options.

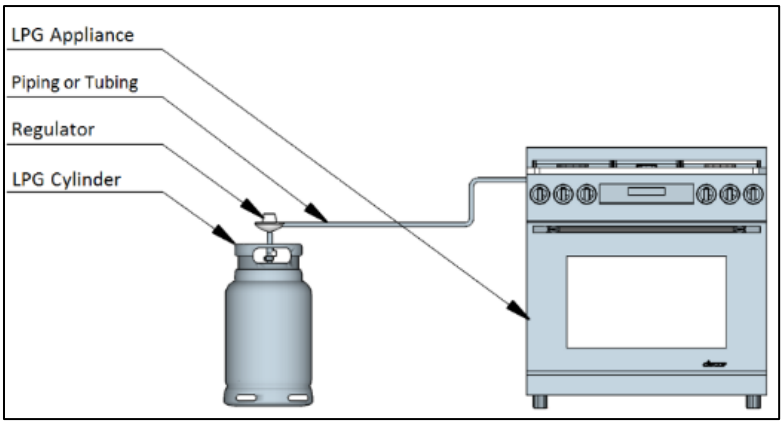
Where there is a concentrated demand pattern, with high offtake, the option of a reticulated system, with a large central storage facility supplying LPG through a piped network, becomes favourable.

Displacing cylinders with a reticulated supply make good sense if the economics of investing in the infrastructure justifies it.

Globally there are limited examples of reticulated LPG systems, but this guide brings the experience and knowledge of those examples into one document.

3.0 What is a Reticulated LPG System?

Most LPG users are supplied with their own individual cylinder, providing LPG to just the one consumer, household, or application. This model has been in existence since LPG has been used as a modern energy, but it has its challenges.



Components of a basic LPG domestic supply

To provide each consumer with LPG the LPG distributor requires at least two cylinders to sustain a continuous supply. One cylinder with the consumer, and at least one more in support somewhere in the distribution channel, the filling plant, the distributor, or the retailer.

Contrast this to a reticulated LPG system where a central supply source can supply a large group of end users. Reticulated systems simplify the logistics side of the business and offers many benefits to all parties, end user, property owner and LPG supplier.

3.1 Pure LPG System

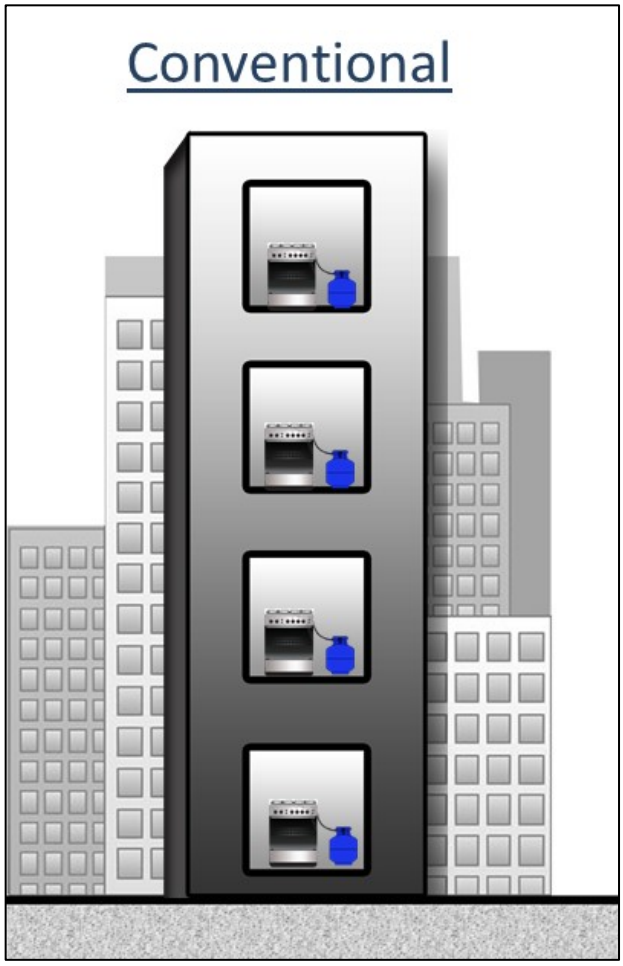
Reticulated LPG systems - also called piped or centralised systems - have a network of LPG pipes connecting multiple users to a common supply source. They are also referred to as centralised LPG supply and distribution systems, or piped LPG systems.

The centralised supply can either be from a multi-cylinder installation, or a bulk installation. In the simplest form, a single row of apartments can be reticulated, although this is not so common.

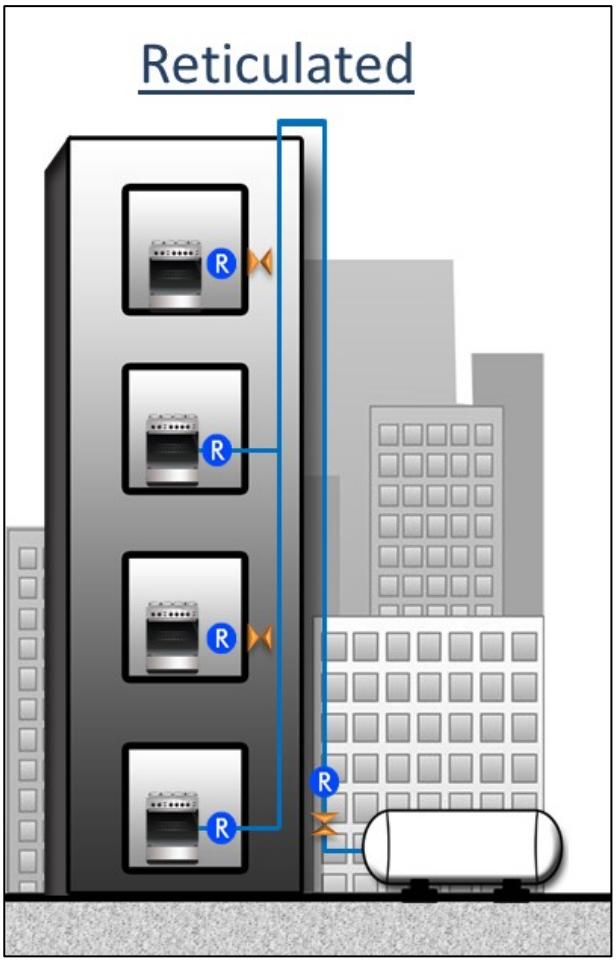
More common is to reticulate a residential building, or a cluster of residential buildings, that may also include a shopping or commercial complex containing restaurants and other enterprises needing a supply of gas.

In Japan it is common for domestic LPG consumers to be supplied from LPG cylinders, which are located outside the property, that are connected to a small piped system into the household through a meter. One cylinder is active while the other is on standby. This concept is probably the earliest form of piped system developed for the LPG industry. But it still requires discrete cylinders to support a single consumer.

Reticulated LPG systems take this Japanese model one step further to one where the LPG supply is from a single source supplying more than one consumer. In Hong Kong there are many high rise residential/commercial buildings serviced with reticulated LPG systems supplying tens of thousands of consumers from one bulk facility. Entire townships can also be reticulated.



Individual residential apartments being supplied with LPG using cylinders



The same individual apartments being supplied with LPG through a reticulated system from a central storage facility

Reticulated LPG systems can be very large. The Bonifacio Global City in Manila, The Philippines - covering an area of 240 hectares - is reticulated with LPG (see Appendix Five).

These reticulated LPG systems not only provide a very efficient and safe way of supplying LPG to consumers, but they also eliminate the need for individual cylinders and all the challenges that come with that.

A reticulated LPG system is capital intensive and so before investing in the infrastructure there are some key issues to address including the contractual arrangements (exclusivity of supply), the LPG demand assumptions and pricing mechanisms (influencing the economics of the project), and the question of whether LPG cylinders will continue to be supplied into the building (creating an unwanted competitive alternative).

Managing the system will require skilled manpower to operate and maintain the facilities. Managing the stocks will also be a critical activity to avoid stock outs. There are many telemetry tools available using the internet of things (IoT) to assist with this.

Examining potential added business opportunities, such as appliance sales, should also be considered.

Reticulated LPG systems can only be used with LPG. Natural gas (NG) has a much lower calorific value and requires larger diameter pipes and appliances with larger apertures. LPG/Air systems are an option though and require a small facility where LPG and Air are mixed, and then stored in pressure vessels and pipelines within the building or complex.

3.2 Synthetic (or Simulated) Natural Gas System (SNG)

If LPG is to be used in conjunction with natural gas, the concept of synthetic (or simulated) natural gas (SNG) can be considered. SNG systems are also called LPG/Air systems. They are designed to dilute the higher energy LPG to match that provided by NG, allowing the interchangeability of the two fuel gases without the need to change equipment or gas appliances.

This matching is achieved through the Wobbe index which is calculated using the calorific value and specific gravity of both gases. Gas equipment can use different gaseous fuels as long as they present the same Wobbe index.

> The Wobbe Index (WI) is calculated by dividing the higher calorific value of the fuel by the square root of its specific gravity. The specific gravity is calculated by dividing the density of the gas (e.g., LPG) at standard conditions by the density of air at standard conditions. The WI is used to compare the combustion energy output of different composition fuel gases in an appliance (fire, cookstove etc.). If two fuels have identical Wobbe Indices, then for given pressure and valve settings the energy output will also be identical. Using WI, the LPG/air mixture can be calculated to ensure compatibility between the NG it is being matched with. Typically, variations of up to 5% are allowed as these would not be noticeable to the consumer.

SNG systems would typically be reticulated to allow interchange with NG or to provide a backup to the natural gas supply in the event of peak lopping or NG supply failure. They are designed to 'dilute' the LPG with air to produce a mixture and should not be used to supply 100% LPG.

Depending on the size, a SNG system can be supplied from either a multi-cylinder bank of large LPG cylinders or from a bulk installation. The sizing of the storage required should consider demand peaks and supply restrictions due to weather etc.

A small SNG system - courtesy of ITO Europe

SNG systems are a useful option to use to establish a demand base before Natural Gas (NG) arrives. They are very cost efficient and uncomplicated and provide a mixed energy portfolio without fear of having stranded assets later when NG does become available.

4.0 Advantages and Benefits

Reticulated LPG systems offer advantages to all stakeholders. The alternative to reticulated systems is to supply LPG through a discrete small bulk system or provide LPG in cylinders.

Reticulated systems can be used to supply low rise buildings too

The key advantage of a reticulated LPG system is that it allows consumers to experience the benefits of a piped gas supply without the constraints of having to be connected to a natural gas grid and without the disadvantages of having LPG supplied by cylinders.

As with a natural gas system, if there are supply problems, they can affect numerous consumers at the same time. This can be mitigated by designing the supply system to isolate sections and have numerous clusters of consumers. Gas supplies to a multi-story building for example could have separate downpipes, with isolation valves at the top of the building controlling just one side, allowing that part of the building to be isolated. This is also useful in an emergency when sections of the pipework have to be isolated.

Good preventative maintenance programmes will mitigate against unplanned system shutdowns. The maintenance regime is the same as for a bulk storage system except there are more pipelines and pressure control systems to inspect.

All reticulated systems are built to last as long as the property, but they will need periodic maintenance including equipment replacement to achieve a long service life.

4.1 To Consumer

- Uninterruptable supply – reticulated systems provide an uninterruptable gas supply with consumers not needing to be concerned about running out of gas due to an empty cylinder

- No waiting – there is no need to worry about re-ordering and waiting for the delivery of gas

- Aesthetical appeal – there is no requirement for LPG cylinders to be present in the property with the associated storage space requirement, possible injury moving them, and potentially damaging the property

- Convenience and security – there is no need for LPG delivery personnel to enter the property, meters can be read remotely

- Economical – payment is made after consumption and there are no cylinder delivery charges or residual product in ‘empty’ cylinders

- No maintenance concerns - comprehensive maintenance contracts could include periodic inspection and monitoring for a nominal charge

- Consumption transparency – connection is fitted with a meter to record consumption

- Safety and security – no cylinder/regulator leaks from incorrect fitting
- Less risk - no cylinders are in the property bringing possible lower insurance premiums
- Added value - reticulated systems typically add value to the property

4.2 To the LPG Supplier

- No cylinders - residential LPG cylinder customers will typically require more than two cylinders to sustain supply, one active and the others in the distribution channel
- Only dealing with one customer – typically a dealer will be responsible for managing the complex including reading the meters, invoicing the consumers, and collecting the outstanding payments
- Contracts - long term contracts bring security to the business with reduced threat of switching
- One delivery point – regular bulk deliveries of LPG into a single storage installation
- Economy – reticulated supplies are typically charged at a higher rate ($/kg) than cylinder supplies

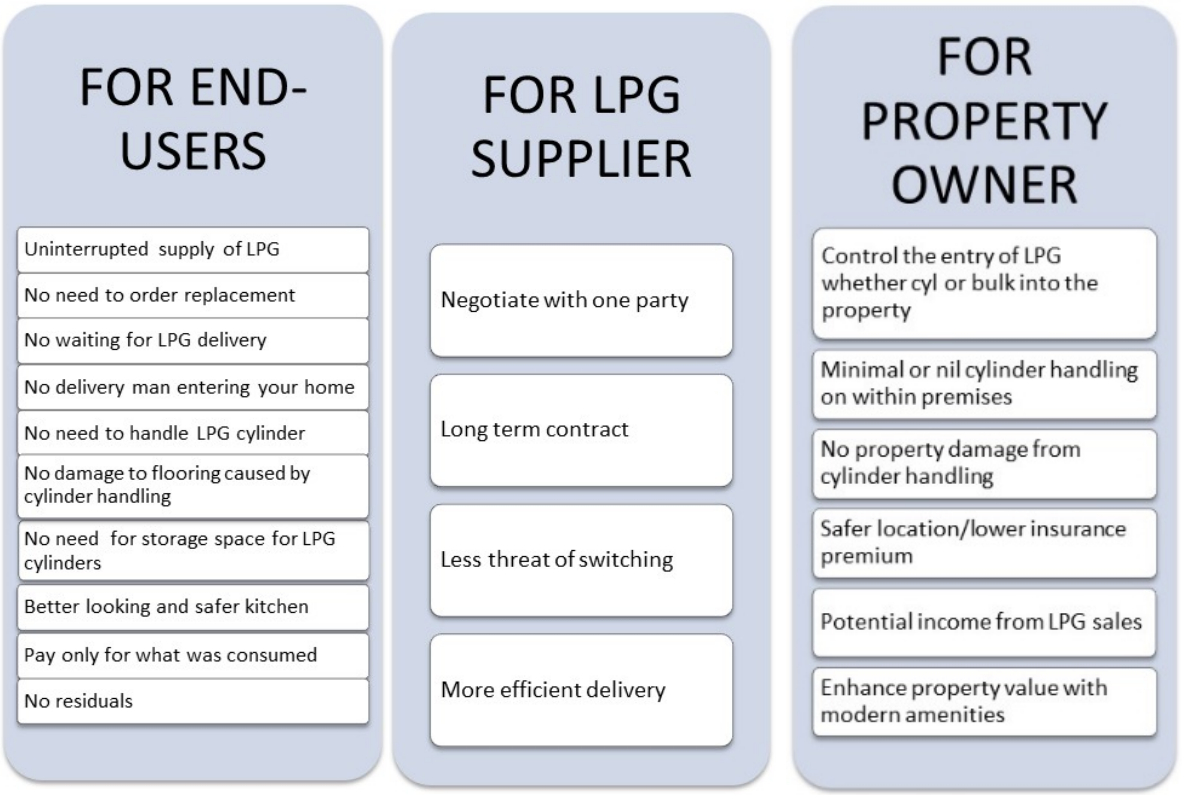
4.3 To the Property Owner

- Control - over the entry of LPG into the building
- No cylinders – eliminates cylinder handling issues
- No damage – to property from cylinders
- Safer – increased building safety with the possibility of lower insurance premiums
- Income - potential income from LPG sales
- Value - enhanced property value with modern amenities

Reticulated LPG systems enhances the property value

- Commercial – attractive gas utility services for commercial businesses

Summary of advantages of a reticulated LPG system:



5.0 Application of Reticulated Systems

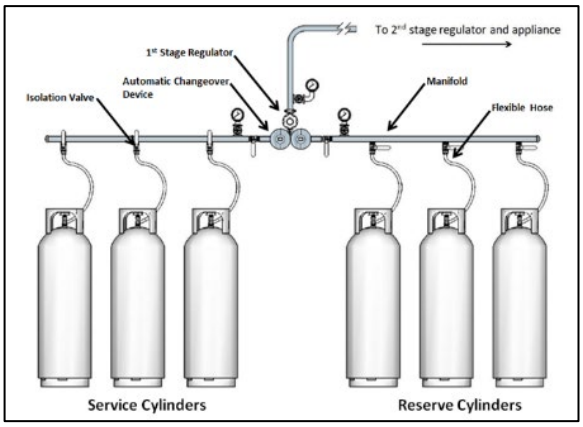
Reticulated LPG systems can be applied across all sectors but are most commonly used where the demand for energy is sustained and centralised. The system is capable of providing a metered supply of LPG to any type of consumer but preferably consumers that require significant demand needs to justify the investment in the storage and distribution infrastructure.

5.1 Residential

In its simplest form, reticulated systems can be used to supply a single household. In Japan households are commonly supplied from a pair of domestic cylinders which are located outside the building. One cylinder will be in service and the other on standby.

An automatic changeover valve will ensure continuous supply though pipework connected to a regulator and meter. The consumer receives an invoice each month and never has to worry about reordering cylinders. The LPG supplier takes care of that.

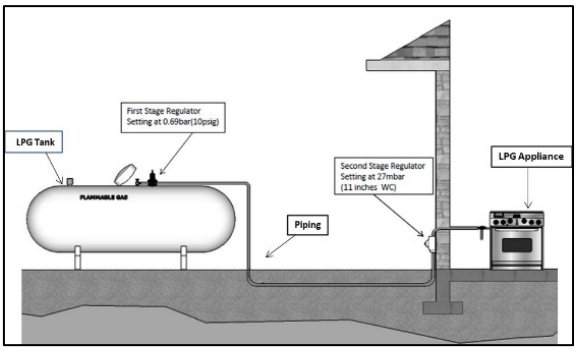
Smaller reticulated systems can be supplied from multi-cylinder banks with an automatic changeover valve ensuring continuity of supply.



LPG cylinder bank storage system

Small bulk tanks supplying a single consumer, or multiple users, are also common but this guide is focused on supplying a large number of consumers from one bulk facility.

One of the largest single reticulated systems in the world is in Hong Kong. The Hang Far Chuen estate supplies 6,560 residential households, and a large commercial complex with a shopping centre, with restaurants and fast-food outlets, from a 40,000 metric tonne (kMT) mounded storage facility located nearby.



Simple bulk LPG storage system

Residential demand in these types of installations include cooking, water heating, and in some countries room heating. Other applications could also include refrigerators and air conditioning systems driven by LPG, including LPG driven co-gen and tri-gen units.

5.2 Commercial

Commercial consumers include hotels, and restaurants, including fast food outlets. These types of businesses are often part of, or adjacent to, large residential complexes and so a reticulated LPG project could include both residential and commercial consumers.

Experience from this type of business, that has commercial embedded in a residential complex, indicates that the commercial demand can provide up to 30% of the total demand. Also, this demand is not subject

to concentrated periods of demand as residential demand is. Residential demand can often be concentrated in just a few hours a day during early evening when demand for cooking and water heating is at its highest.

Another large commercial application for reticulated systems is hotels where there is high demand for cooking, water, and room heating. Some commercial complexes may also have demand for power generation systems, either base load or standby.

5.3 Industrial

Industrial consumers are often concentrated within an industrial estate so instead of each consumer having a discrete bulk tank there might be an opportunity to supply the whole estate from a central storage system and meter the gas to each industrial consumer.

LPG supplying an industrial estate

LPG has very clean burning characteristics and is suitable for many industrial applications where a clean burning flame is needed. This includes applications in the food industry.

5.4 Townships

Entire townships, covering areas in excess of 200 hectares, have been reticulated with LPG. The Bonifacio Global City in Manila is one example (see Appendix Five).

This type of LPG reticulated system becomes a flagship project for piping LPG into centres of high energy demand.

Bonifacio Global City, the Philippines

6.0 Business Model

Piped gas systems can either be installed when the building is being constructed, or they can be retrofitted to an existing building that is being upgraded to include a gas utility.

Installing the LPG system as the building is being constructed not only reduces the cost of installation it also creates an opportunity to work closely with the developer. This provides the opportunity to reinforce the confidence in LPG reticulated systems with third parties including architects, developers, contractors, and tradespeople.

The investment cost for installing the whole installation is significant. It will include storage installation, equipment, pipework, and appliances, together with investment to ensure safe and efficient access to the storage facility by bulk LPG road tanker. Landscaping of the storage facility may also be required to blend it in with the surrounding buildings.

This up-front investment in a complete reticulated system will need to be made before any gas is sold and will involve negotiations with the developer.

The right to supply gas to the building could arise from a tender, or a separate negotiation with the developer. Because of the potential size of investment, the viability of the business case will depend on the period of the supply contract, and the exclusivity of supply.

Once the system is installed, it is in the interest of the gas supplier to encourage usage of gas as soon as the building is occupied. Supplying gas consuming appliances will not only enhance the value of the property it will also encourage gas consumption as soon as the property is occupied. In a residential property the two appliances that typically consume most gas are the cooker and water heater. Depending on the circumstances the installation of the reticulated system could include those appliances. There may also be other appliances such as refrigerators and air-conditioners.

As with any piped gas system into a building, it is better to install the pipework when the building is being constructed. This is especially true for a high-rise multi-story building, where the external and internal pipework can be installed to each floor of the building utilising the scaffolding. This requires close collaboration with the developer.

For existing buildings, the installation of an LPG reticulated system may be more complicated but still viable. Ownership of the property may have passed from the developer to the occupiers, but the attraction of a utility gas supply should encourage the design to install.

There will be a need for several different contracts during the installation and running of a reticulated system but one of the most important ones is the contract that secures the business opportunity between gas supplier and developer.

One of the key issues to consider for the gas supplier is the obligation to design, supply, construct and install an entire LPG storage and distribution system at the particular lot, and in the buildings, for the supply and distribution of LPG over a specified period upon the terms and conditions contained in the contract.

Probably the most common form of business model for reticulated systems is for an operating company (dealer) to represent the LPG supplier by managing the business locally. The managing company's role would be to take care of all aspects of the installation from the storage facility to the consumer.

This would include monitoring LPG inventory and arranging replenishment stocks, overseeing all the equipment from primary regulation, through the entire piped network, to the consumer interface.

The consumer interface would include meter reading, invoicing, billing and collecting outstanding's. There would also be a need for the company to provide customer service support through a customer service centre. The company would also be responsible for handling any emergencies with any part of the distribution system.

Another important issue is what happens at the end of the contract period. There should be clear obligations for both developer (or property owner) and gas supplier to ensure both can extend the supply contract if agreeable to both parties. If not, there should be arrangements in place to ensure a transfer of ownership in a fair manner without threatening the supply of gas to the consumer.

6.1 Consumer Billing (Post Paid)

Unlike the LPG cylinder business, where consumers generally pay for the entire contents in advance (unless smart meters are involved), reticulated supplies are delivered and consumed before payment. This requires a degree of credit as well as presenting a degree of risk.

The credit is to cover the time between the managing company paying for the bulk supplies and the consumer using and being invoiced based on the, generally monthly, meter reading.

The credit risk is when the consumer uses a months' supply or more of LPG and then doesn't pay the invoice. This can be partially mitigated by charging a deposit on the meter which would typically be around the cost of a month's supply of LPG.

6.2 Prepay System

In the past, coin in the slot meters were used with reticulated gas systems which was the first of the pre-pay systems. Coins were inserted into the gas meter allowing a handle to be turned to allow a predetermined supply of gas to be used.

These coin meters were first introduced with towns gas systems in the 1950's but have now been superseded with smart meters. Smart meters can be linked to smart devices - such as phones and tablets – banks accounts, and LPG suppliers, allowing a predetermined amount of gas to be used before the smart meter shuts off the supply. Smart meters can also be linked to the smart devices to warn consumers of an impending gas out situation allowing consumers to buy more gas avoiding a stock out.

One of the early coin meters from the 1950's

Although smart meters were developed for use with single LPG cylinders, they are also suitable for piped supplies. The advantage of smart meters is they eliminate the need to have access to the property because they can be used remotely.

The use of telemetry also allows for the remote monitoring of storage tanks by both the LPG supplier and the company managing the property.

7.0 Key Components of a Reticulated System

The master plan for a large, reticulated project supplying LPG from a bulk central storage location in Hong Kong is shown in Appendix Five. There are several residential blocks, each block being supplied with LPG through risers leading to ring mains running around the top of each block.

Whether the system is large or small the basic components of a reticulated LPG system are the same. These will include the storage compound where the central LPG supply is located nearby, the equipment required to present the gas to the network, a piped network supplying LPG to the various offtake points, and finally the meters, appliances, and safety devices at the point of consumption.

Typically, a domestic household using LPG cylinder will have one cylinder in use and perhaps another on standby because they never know when the first cylinder will become empty. In addition, there will be one or two cylinders either in the filling plant or in the distribution channel supporting that household.

The key difference between an LPG cylinder supply and a reticulated LPG supply shown in **Appendix Five** is that the central storage facility replaces the need for over 30,000 cylinders. This creates advantages in that these cylinders do not have to be checked, maintained, and refilled in supporting the consumer. Instead of individual domestic cylinders, the supply of LPG through a reticulated system is either through a bank of large industrial/commercial cylinders or a bulk storage facility.

7.1 Storage System

There are two options for the type of storage system supplying LPG to a reticulated project and the choice will depend on the criteria and type of installation. The following summary is a guide for that decision:

Multi-cylinder installation

- Generally small consumption
- Can be with or without vaporiser
- Restricted space
- Requires access for cylinder truck
- Simple installation
- Cylinder handling issues
- Residual gas concern

Small multi-cylinder LPG storage facility

Bulk installation

- Can be above or below ground
- Can be with or without vapouriser
- Requires bigger space

- Requires access for bulk road tanker
- Operationally simpler
- Higher initial cost
- No returned gas (in cylinders)

Large underground bulk LPG storage facility

The storage facility is the heart of a reticulated LPG system. The demand profile, including the need to cope with periods of peak demand, will influence the type and size of storage required. It is also one of the factors that determine the feasibility of providing a reticulated supply because of the need for space to store the LPG. Safety distances to other buildings and access for LPG delivery vehicles (large cylinder trucks or bulk road tankers) are two important factors.

Access for the delivery vehicle is very important. The vehicle should be able to enter and leave the storage facility, preferably without having to reverse. When the vehicle is parked the operator should have line of sight between the vehicle and the inlet connection on the storage vessel.

Supplying reticulated LPG to a large residential complex with thousands of households can require a significant storage facility. The facility shown here was designed to supply around 6 metric tonne (MT)/day from the storage compound consisting of two underground storage tanks, each of 20MT capacity. This was sufficient to provide around a weeks' storage. For this amount of on-site storage, a risk assessment would likely be a requirement.

Having two storage tanks allows periodic maintenance to be conducted on one tank without impacting supplies to consumers.

Parking bay for bulk LPG road tanker with fire-fighting facilities

Both mounded and underground storage allow the compound to be located closer to the residential and commercial complex because of the reduced safety distance requirements.

It is good practice to bury storage tanks in reinforced concrete underground chambers and back fill them with dry washed sand. The storage tanks should also be protected from corrosion using a surface coating such as a bitumen paint, supported with a cathodic protection system.

The bitumen protective surface is soft and can be easily damaged with the slightest knock. Great care must be taken when

Underground LPG storage tank being lowered into position

manoeuvring the tank into position on its supports inside the concrete chamber.

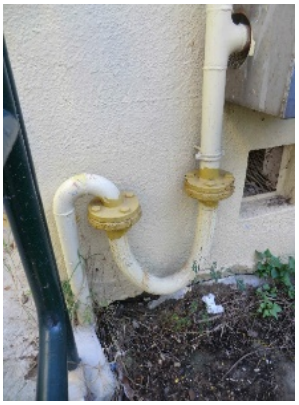
Cathodic protection is a technique used to control the corrosion of a metal surface by making it the cathode of an electrochemical cell. A simple method of protection connects the metal to be protected (the tank) to a more easily corroded 'sacrificial metal' to act as the anode. The sacrificial metal then corrodes instead of the protected metal. It is good practice to have easy access to the anode to allow regular monitoring because soil quality varies resulting in different corrosion rates.

The storage tank will have several openings, but it is good practice to cluster fittings on a single manhole cover to minimise tank openings. The manhole also allows access for periodic internal inspection of the tank surfaces.

Tank fittings clustered onto a single manifold

LPG in its liquid phase has a density of around half that of water. So, any full vessels – cylinders, tanks, road tankers etc – must be secured if located in an area that is at risk of flooding. This especially relates to underground storage tanks which need to be strapped into position in the event the chamber is flooded. LPG tanks will float away very easily!

Tanks located in underground concrete chambers should be back filled with dry washed sand and topped with concrete slabs. This allows safe and easy access to the storage facility without risk of tripping. All pipework fittings should be clearly marked to indicate liquid and vapour lines and direction of flow.



Flexible joint at the base of a riser

Cylinders supplying LPG to a reticulated system should also be secured to prevent damage in the event of accidental falling or flooding. Cylinder banks should be designed in pairs with one in active service and the other on standby. Automatic changeover devices will ensure the system maintains a gas supply once the active bank becomes empty.

In countries where there is a risk of earthquakes, mitigating measures should be built into the design of the facility such as earthquake monitoring devices and flexible couplings and flexible couplings and pipework.

Earthquake sensors - courtesy ITO Europe/The ITO Corporation

This is particularly important where the pipework connects to the building as rigid pipelines may be subjected to stress and potential failure if the building moves.

7.2 Vapourisers

If natural vapourisation of the LPG liquid in the tank is insufficient to meet peak demand, then vapourisers can be used. Vapourisers are introduced into system design as a way of producing LPG vapour from the LPG liquid.

ITO vapourisers - courtesy ITO Europe/The ITO Corporation

Vapourisers are rated on their capacity. The vapourisers installed in the complex here each have a capacity of 750kg/hour. These vaporisers are the hot water type, with the hot water heaters supplied by LPG.

LPG vapourisers - courtesy DCC HK

As with all the other key components in the design it is good practice to build the vapourisers in parallel to facilitate maintenance and manage breakdown issues.

7.3 Pipework

Steel pipes and steel pipe fittings are commonly used for distributing LPG through piped networks. For medium to low pressure systems schedule 40 pipes is suitable. Screwed connections are allowed for up to 50mm (2") diameter, but for larger than 2" diameter, welded or flanged connections should be used.

For underground piping, medium density polyethylene (MDPE) pipe is recommended. There are various advantages in using MDPE, but they must not be exposed to sunlight, or used where there is a risk of accidental puncture.

Copper can also be used but it is not common. For more information on material choice (see **SECTION 8.0 DESIGN AND INSTALLATION)**.

There are some basic rules for gas piping design and routing regardless of the material used.

- Minimise the length of gas pipe used
- Locate at least 300mm from other utilities when the pipeline is buried
- Protect the pipe from physical damage and corrosion
- Sleeve the pipework if passing through walls
- Provide ease of access for inspection and maintenance
- Pipework should not pass-through basements, or sewer lines unless sleeved
- There should be adequate test points

- Allowance for thermal expansion and/or vibration and movement (- 0°C to 30°C will cause steel to expand by 33mm/100m)
- Provision should be made for emergency shut off valves
- Isolating valves should be fitted at both ends for pipes crossing roadways
- Pipework should be isolated by section to carry out servicing
- There should be proper depth of cover for underground pipes
- 1.0m below load bearing roadways
- 0.6m below pedestrian walkways
- If the depth of cover cannot be attained, a sleeve can be provided as added protection for shallower depth. A tracer tape should be installed to identify the pipework
- Non-metallic flexible connectors to be avoided if practicable
- Consider Cathodic Protection for pipework in contact with the ground

7.4 Regulation

The pipework delivers the LPG from the vaporiser room to the appliances in the apartments and commercial complexes.

First stage pressure regulators

For large multistorey buildings LPG is first taken from the storage system to the top of the building. The first stage pressure regulator should be located near the storage system.

LPG vapour is drawn off the tanks at tank pressure and enters the first stage of pressure regulation. This is typically around 0.7bar (10psi). Anything greater than 2bar (29psi) may cause vapour condensation during low temperature conditions. It is good practice to set the first stage of pressure reduction as low as practicable consistent with the requirements, and local regulations.

LPG risers

The vapour is then directed to the roof of the buildings where the pressure is reduced again to around 0.07bar (1psi) in the second stage or pressure regulation.

The third and final stage of pressure regulation occurs at the meter which reduces the pressure to 0.03bar (12 inches water gauge) before entering the appliance.

As with other equipment, it is good practice to have first and second pressure regulation designed in parallel to allow for periodic maintenance.

Automatic shut off controls prevent abnormally high, or low-pressure gas from entering the premises. The UPSO (under pressure shut off) device, cuts off the gas flow in the event of an abnormal fall in pressure. This can be caused, for example, by flow rate exceeding the capacity of the gas installation, (cylinder size, pipework sizing, wrong regulator etc.), or if there is a run out of gas. They are normally associated with bulk tank supply.

Ring main on top of a multistorey apartment block

An overpressure shut off (OPSO) device operates on the inlet to the regulator control orifice and shuts off the supply of gas at a pre-determined setting. Over-pressure is sensed on the outlet side of the regulator. Manual reset is required to restore supply.

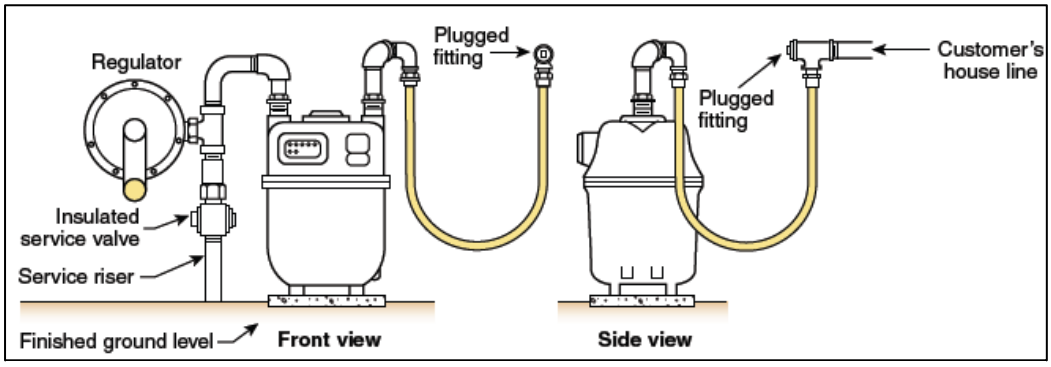
The setup opposite ensures no interruption due to a ready stand by stream. One stream is set at a slightly higher setting and is the primary regulator, with the other on stand-by.

If a short down time can be tolerated it is possible to use a single stream regulator, but it must have a by-pass connection.

Regulators should be located outdoors where possible. If indoors, they must be vented to atmosphere. They should be equipped with OPSO and UPSO as necessary. The outlet setting should meet the appliance requirement

7.5 Meters

The purpose of a meter is to accurately measure the amount of gas consumed by the end user.



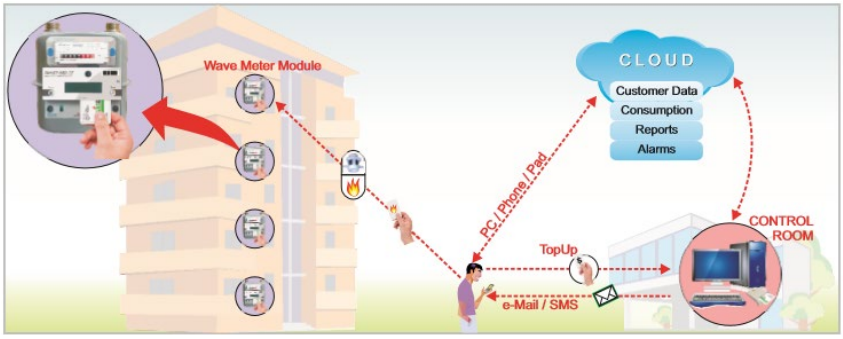
Schematic layout of meter connections

It is at the meter where title of the gas transfers from the supplier to the consumer and so they must be accurate and well protected from both damage and interference.

LPG is normally sold by mass (kilogram [kg] or metric tonne [MT]) but meters measure volume (cubic meters [m3]) and so there is a need to convert meter reading from cubic meters into kg for billing. Discuss and agree method to convert meter reading from kilograms to cubic meters. Temperature compensated meters remove the effect of temperature on the reading.

Meters are typically read monthly. Where meter reading was once a manual operation, requiring access to the consumers apartment or business, telemetry can now be applied to read meters remotely.

This is more convenient for both the consumer and the gas supplier.



Remote meter reading

Prepay systems can now be used with smart devices and the IoT. This may be a preferred payment option for some consumers and mitigates the risk of non-payment and fraud.

Example of a smart meter

Some general rules for the application of meters include:

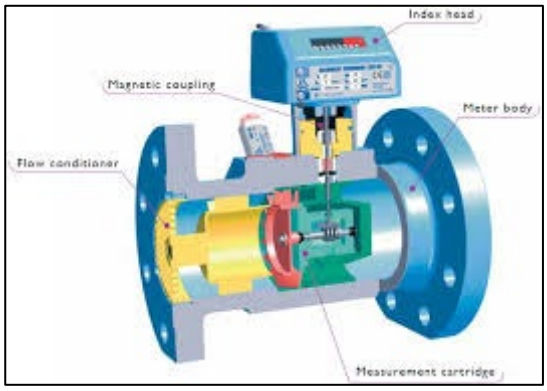
- Locate in well ventilated spaces and be accessible for reading, inspection, and maintenance
- Do not subject meters to extreme temperatures
- Protected meters against impact and physical damage
- Meters should be adequately supported
- Locate meters at least 300mm from any potential ignition sources (electricity meter/cable/wiring)
- They must meet the maximum expected pressure and permissible pressure drop
- Use diaphragm type meters for monitoring individual residential and commercial consumption
- Use turbine or rotary type meters for high volume throughput
- Meters made of tin or brass case type soldered construction should not be used for pressures over 1psig
- Locate final stage regulators near to meters

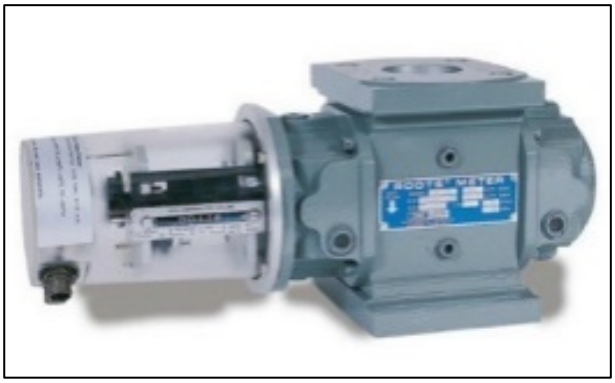
New meter technology has introduced digital ultrasonic meters designed with no moving parts, virtually eliminating the cost of repairs. These meters retain their calibration. They also provide alerts for tampering and for malfunctions. Their compact design affords flexible installation options.

The electronic platform allows automatic meter reading to be done more cost effectively and to upgrade the meter with the latest options while it is still in service.

Vapour (not liquid) meters should be used if supplying more than one user to monitor consumption.

Examples of diaphragm meters





Examples of rotary meters

7.6 Appliances

The main LPG consuming appliances in a domestic installation are cookstoves and water heaters. Commercial applications will also include those but there may also be other applications such as ovens, air conditioning systems, refrigerators, and dryers.

All appliances should match the design of the system being used with particular attention being paid to the quality (propane, butane, a mixture of both, or LPG/air (SNG) mixtures) as well as the maximum and minimum gas pressures under which the appliance will operate safely). The appliance will be sensitive to the Wobbe Index of the gas. This is especially important if the system is designed for natural gas or synthetic natural gas when an interchange of those products is anticipated in the event of peak lopping or stand by purposes.

The decision to invest in a reticulated LPG system will be driven largely by assumptions on LPG demand, and the margin generated through the sales of LPG.

Restrictions on the use of LPG cylinders in buildings may be a threat to LPG usage, especially multi-story apartments, but these restrictions will also protect the investment in a reticulated system from competition from cylinder sales.

Assumptions on LPG demand will be based on variables such as occupancy rate, number of family members, lifestyle (eating out or eating at home), disposable income etc.

Having installed the infrastructure to supply gas to each household or commercial/industrial outlet the investment case will depend on how quickly those meters turn.

For new buildings there may be an opportunity to install appliances as the building is being constructed, along with the pipework and other equipment. Residential apartments will need cookers and water heaters and if these are installed before the apartment is completed and occupied, they will not only add value to the apartment they will also secure LPG as the energy source for cooking and hot water.

The decision to install LPG appliances into a new building should be discussed with the developer. For multistorey buildings there will be a need for perhaps thousands of appliances and there will be opportunities for not only economies of scale but also consistency of spare parts and repair and maintenance later on.

Who pays for these appliances? This will be a discussion between LPG supplier and developer but there is clearly a benefit for both parties. Tenders can be issued to secure competitive prices from appliance manufacturers if the requirement justifies it.

The minimum requirement for a household will be a cooker and water heater but there maybe other opportunities for other applications. A household of 4 or 5 people might use 10-15kg of LPG a month for their cooking and hot water needs depending on their living habits. There may also be opportunities for LPG dryers, refrigerators, air conditioning, and co-gen and tri-gen units.

In large residential buildings it is not uncommon to have commercial activities such as fast-food outlets, restaurants, and launderettes. The pipework supplying LPG to these outlets will need to be sized according to the maximum demand expected.

This will need to be based on the highest demand case to accommodate any future change of use. If a commercial centre is designed into the building there will probably be a need for a gas pipework ring main to be accessible for every outlet, even though the outlet may have no current need for a gas supply.

Where there is no supply of gas required, the tee from the ring main must be securely locked to prevent any accidental or unauthorised access to the gas pipework.

LPG meter installed inside an apartment

Where gas is supplied to the apartments, or commercial/ industrial outlets, a meter should be installed at each point of sale which is easy to access and read. If smart meters are installed they can be read remotely.

Transfer of asset takes place at the meter so they need to be accurate.

7.7 Safety Devices

The importance of safety should never be ignored and many safety features for the system have been described so far. It is equally important for the stakeholders operating and using the system to be knowledgeable about the key safety messages.

Everyone has a responsibility to operate and use the system safely and this must be achieved through knowledge transfer using demonstrations, information sheets and signs.

The following are generally not mandatory in most standards but are recommended to be installed within individual apartment or commercial outlets to enhance safety.

Excess flow valve

Excess flow valves - used to mitigate against a hose rupture that otherwise would allow an uncontrolled leak of gas. The excess flow valve shuts off the gas supply to a minimum, or completely.

Metallic flexible hoses - fitted where there might be excessive movement between gas supply and appliances. They are robust and also can withstand not only movement but impact.

Leak detector with shutoff valve - designed to detect gas leaks and normally fitted in less well-ventilated areas that might be prone to leaks. They should not be fitted as an excuse not to carry out regular checks for leaks in the normal course of good housekeeping and maintenance.

Emergency shut down valves

Emergency shutdown valves – installed in the system to be activated in the event of an emergency when the gas supply can be shut off to isolate any incident.

8.0 Design and Installation

This Chapter covers the design and installation of the piped distribution system focusing on the pipework, and materials used for the pipework. There are other guidelines in the series of WLPGA Good Industry Practices covering bulk storage.

8.1 Existing Codes

There are several well recognised Standards or Code of Practices that are applicable for LPG reticulation systems e.g., NFPA 58, and NFPA 54 (NFPA 58: Liquefied Petroleum Gas Code), and UK COP 22, and UK COP 25 (Liquid Gas UK : Clean, Efficient Energy from the UK Liquid Petroleum Gas Association).

If reticulated systems are being introduced into a country for the first time the application of the UK Codes of Practice are a good reference that could be adapted to suit local conditions. This avoids a situation where contractors and other LPG distributors follow their own standards and codes which may lead to confusion and even unsafe conditions.

Irrespective of the code used, all LPG piping must comply with local laws and regulations.

The UK Code 22 is a comprehensive code for LPG pipework above and below ground. It was updated in June 2020 and covers:

- Temperature, pressure, and pipe sizing considerations
- Pipework assemblies, fittings etc.
- Guidance on construction of carbon, steel, copper and polyethylene pipework
- Guidance on UK legislation
- Covers the testing and installation of pipework

The UK Code 25 is a new publication detailing the design, installation and maintenance of central LPG storage facilities which distributes LPG to multiple properties such as metered estates, residential parks, and holiday parks and covers:

- Planning
- Contract terms
- Pipeline Safety Regulation (PSR) compliance
- Pipework design and water course consideration
- Updated guidance on the positioning of utility apparatus, trench measurements and meter housing placement

8.2 Sizing the Installation

The sizing of LPG installations is determined by peak demand. Demand for energy in domestic installations is centred on activities such as cooking, heating, and hot water usage. Other variables will include country climate and public holidays.

The impact of a pandemic such as COVID-19 on domestic demand has emerged as a new parameter increasing domestic demand – at the expense of commercial demand from restaurants - with lockdowns restricting movement and forcing people to eat at home.

Cooking activities will take place around the three meals of the day, early morning, midday, and early evening. Hot water demand will typically be early morning and evening. Heating demand will be seasonal and dependent on ambient conditions. Peak demand for LPG will be when these activities occur around the same time. If a reticulation system cannot meet the peak demand, appliances will suffer poor performance, or shut-down completely until the gas supply can meet the appliance's demand. Bulk tanks may suffer prolonged periods of 'freezing'.

In designing the LPG reticulation systems for domestic high-rise apartments in Hong Kong it was assumed peak demand would occur during early evening when meals were being prepared in the kitchen and occupants were using hot water to take evening showers in the bathroom.

Some key issues:

- Meet maximum demand
- Design for an acceptable pressure drop
- Allow capacity for future development

Oversize piped may introduce too much gas into the system. Also, there is a need to keep the quantity of LPG within a reasonable limit in case of a leakage.

Gas piping systems shall be of such size and so installed as to provide a supply of gas sufficient to meet the maximum demand and supply gas to each appliance inlet at the minimum supply pressure required at the inlet of the appliance.

Factors to consider include:

- Total Load (kW h)
- Estimated consumption (MT/month)
- Tank evaporative capacity
- Plans for any future development

Determining the maximum gas demand on the system is a critical calculation because failure to meet this demand will result in consumer complaints and loss of sales. Over designing the system results in additional capital expenditure and adversely impacts the financial investment case.

The calculation of the maximum demand will be one of the determinants of the size of piping needed. There are two methods to determine the pipe size - using a formula or using a pipe size table.

The formula method requires several assumptions including the specific gravity and required gas flow in m3/hour.

Formula

$$D = \frac{Q^{0.381}}{19.17\left(\frac{\Delta H}{Cr \times L}\right)^{0.206}}$$

D = inside diameter of pipe (in.)
Q = input rate appliance(s) (cubic feet per hour at 60oF and 30 in. mercury column
H =pressure drop [in. w.c. (27.7 H2O = 1psi)]
L = equivalent length of pipe (ft)

The other method is to use pipe sizing tables.

NFPA 54 Tables 6.2(a) to 6.2 (x)

Gas:	*Undiluted Propane*
Inlet Pressure:	*2.0 psi*
Pressure Drop:	*1.0 psi*
Specific Gravity:	*1.50*

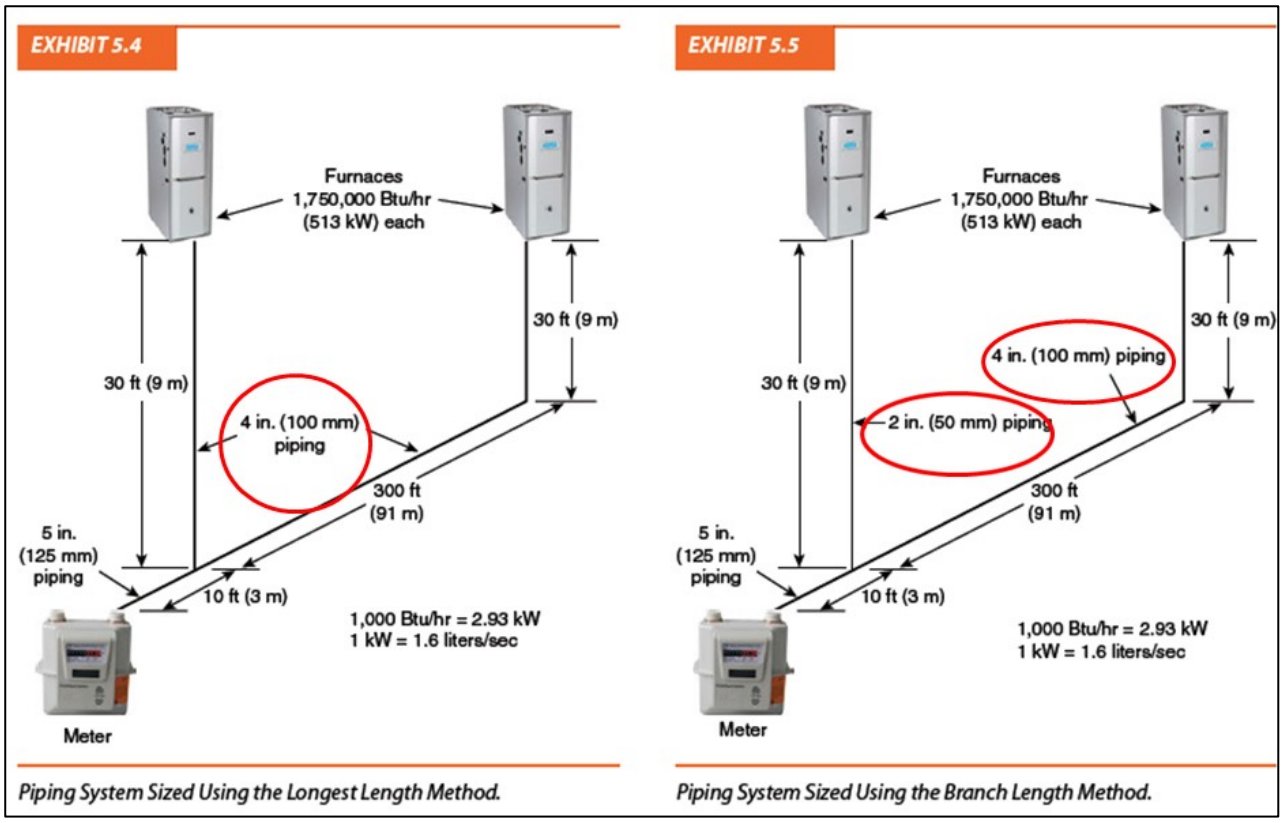
INTENDED USE: Pipe Sizing Between 2 psig Service and Line Pressure Regulator.

	Pipe Size (in.)								
Nominal:	½	¾	*1*	*1¼*	*1½*	*2*	*2 ½*	*3*	*4*
Actual ID:	*0.622*	*0.824*	*1.049*	*1.380*	*1.610*	*2.067*	*2.469*	*3.068*	*4.026*
Length (ft)	*Capacity in Thousands of Btu per Hour*								
10	2,680	5,590	10,500	21,600	32,400	62,400	99,500	176,000	359,000
20	1,840	3,850	7,240	14,900	22,300	42,900	68,400	121,000	247,000
30	1,480	3,090	5,820	11,900	17,900	34,500	54,900	97,100	198,000
40	1,260	2,640	4,980	10,200	15,300	29,500	47,000	83,100	170,000
50	1,120	2,340	4,410	9,060	13,600	26,100	41,700	73,700	150,000
60	1,010	2,120	4,000	8,210	12,300	23,700	37,700	66,700	136,000
70	934	1,950	3,680	7,550	11,300	21,800	34,700	61,400	125,000
80	869	1,820	3,420	7,020	10,500	20,300	32,300	57,100	116,000
90	815	1,700	3,210	6,590	9,880	19,000	30,300	53,600	109,000
100	770	1,610	3,030	6,230	9,330	18,000	28,600	50,600	103,000
125	682	1,430	2,690	5,520	8,270	15,900	25,400	44,900	91,500
150	618	1,290	2,440	5,000	7,490	14,400	23,000	40,700	82,900
175	569	1,190	2,240	4,600	6,890	13,300	21,200	37,400	76,300
200	529	1,110	2,080	4,280	6,410	12,300	19,700	34,800	71,000
250	469	981	1,850	3,790	5,680	10,900	17,400	30,800	62,900

(1) Longest length method – simple and effective for all piping systems. Pipe size determined by using the longest length of piping from delivery point to the Remotest appliance.

(2) Branch Length method – could yield slightly smaller pipe diameters. Pipe size for each section or branch is determined separately by the longest pipe run from point of delivery to the remotest outlet in each branch.

(3) Hybrid length method – Pipe size for each section is determined using the longest length of piping from point of delivery to the remotest line pressure regulator. The pipe size from the line pressure regulator to each outlet is determined by the length of the piping from regulator to the remotest outlet served by the regulator.



An approximate indicative range of some typical estimates of demand are:

- Domestic household (10kg – 20 kg/month)
- Restaurant (500kg – 1500 kg/month)
- Hotel (5MT – 15MT/month)
- Shopping Malls (20MT – 60MT/month)

Note these are indicative estimates. Some larger restaurants can consume up to 5MT/month, especially Asian restaurants cooking stir fry dishes.

Fast food outlets typically consume 1MT/month. When estimating LPG consumption for shopping malls, without other more detailed information it may be possible to use 0.5MT – 0.8 MT/restaurant/month as a rule of thumb.

Hotels that use LPG boilers and do their own laundry then consumption will be high. Large shopping malls can reach 100MT/month with huge differences between peak loads and stand by loads.

8.3 Selecting the Pipework

There are two main options when choosing the material used for pipework and fittings: steel or polyethylene (PE).

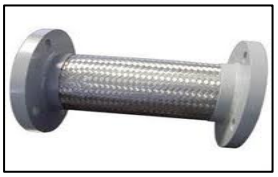
Steel has been the preferred material used for above ground pipework delivering the LPG from the storage facility, firstly in liquid form to the vapourisers, and then in vapour form to the pressure regulators into the main supply system. Copper can also be used but is not common.

For pipework handling medium to low pressures schedule 40 steel pipework is suitable. Screwed connections are acceptable for up to 50mm diameter but anything larger than 50mm diameters require welded or flanged joints.

If the pipework is going to be buried underground, it is good practice to use medium density polyethylene (MDPE) pipework and fittings. There are a number of advantages for using MDPE pipework underground. If there is any risk of the pipework being accidental punctured MDPE should not be used.

If pipes are passing through walls, they must be sleeved, and should never be installed in cavity walls in case of undetected leakage risks into the cavity. Pipes must also be adequately supported throughout.

Flexible connections should be used if there is any risk of the building moving, or any risk of ground movement (earthquake), or any possibility of movement as a result of expansion.



The following is a guide when choosing the material for pipework:

Carbon Steel Pipes

- Use seamless BI pipes A53 (they can withstand heat)
- Use schedule 40 after the 1st stage regulator
- Joints can be screwed when the pipework is up to 50mm diameter
- Use welded or flanged joints when the pipework is over 50mm diameter
- Can be used for above or below ground applications

Typical steel piping

Medium Density Polyethylene (MDPE) Pipes

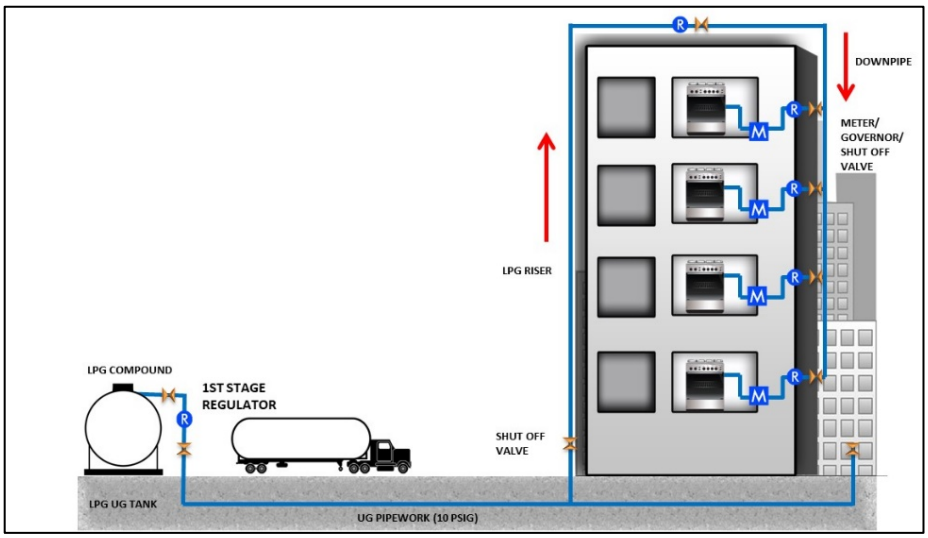
- Use PE 80 SDR 11
- MDPE pipes are easy and quick to install

- The joints are generally of better integrity joints with electric fusion
- They should only be used for underground applications
- Exposure to sunlight should be minimised to avoid rapid UV degradation of the MDPE
- They are corrosion resistant
- Avoid the risk of MDPE pipework from being punctured through location and use of tracer tape in the trench above the pipework

8.4 Routing the Pipework 26

The pipework supplying LPG to the buildings should route the gas to the highest point, or top of the building, first where the pressure can be controlled via the second stage regulator.

From the top of the building the gas can be distributed through downpipes to each point of application. This ensures balanced pressure distribution.



LPG pipework first goes up, and then down, the building

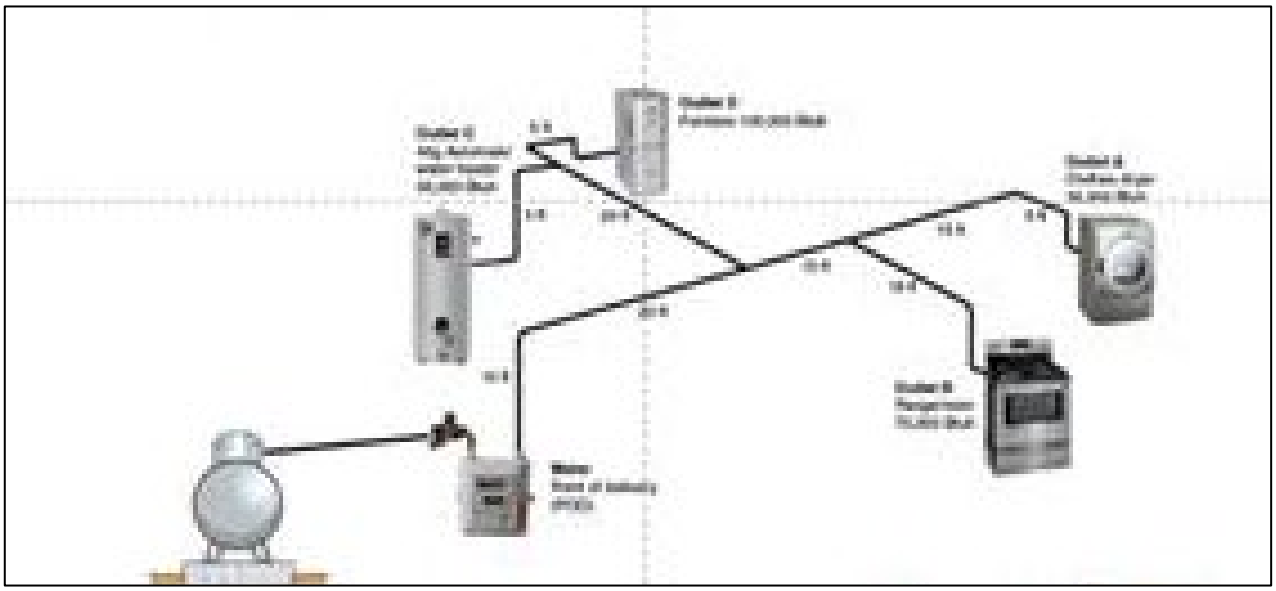
When designing the routing of the pipework take account of the future need to isolate certain parts of the distribution system in the event of an emergency or for routine maintenance and repairs. It is important to minimise disruption to gas supplies by retaining the ability to isolate only those consumers that are affected.

Some other general comments about the routing pipework include:

- Above ground pipework and well supported should be routed to minimise the possibility of:
    - Trip hazard

- Inadvertent physical contact
- Physical damage from moving vehicles or equipment
- Misuse

- Piping should not be laid under:
  - Foundations of buildings
  - Footings of load bearing walls
  - Floating raft foundations
  - Piping should not run through an unventilated space
  - Piping inside buildings should not be installed in chimneys, clothes chutes, elevator shafts, dumb waiters, or air ducts
  - Piping should be looped (ring main) to ensure a balanced distribution of pressure



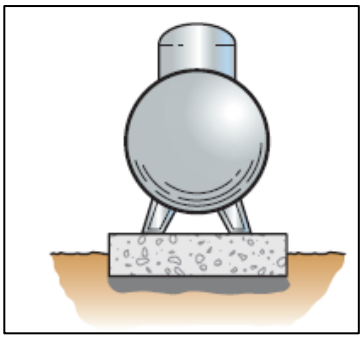
Sketch the layout first

When designing the routing, start by preparing a sketch of the piping layout showing location, different branches, gas appliances (including possible future applications) and their consumption.

8.5 Installing the System

Details for the installation of the LPG storage tank for reticulated LPG systems is described in the WLPGA Good Industry Practice Guide to Bulk LPG Installations (2020 Guide to Good Industry Practices Bulk LPG Installations Pages 1 - 50 - Flip PDF Download | FlipHTML5).

There are some general guidelines to consider when installing a reticulated LPG system:

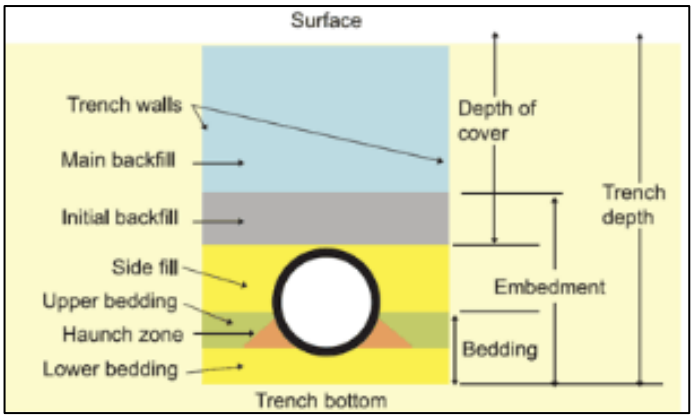


Secure the LPG storage tank

- The number of fittings should be minimised to limit the potential risk of gas leaks
- Tanks and pipework must be suitably anchored and supported to ensure pipe stress and deflections are minimised and within limits
- A main valve must be provided as near to the entry to the building as possible, and easily accessible in case of emergency
- The main valve must be located where it can be accessed with full consideration where a possible fire might impact
- Pipe entry into a building should avoid the basement if possible
- LPG pipelines should be colour coded for clear identification; the international standard colour for gas pipes is yellow
- Avoid the need to pass pipework through concrete floors and walls. Provide sleeves, and seal the space around the sleeve, if it is essential
- The portion of aboveground pipework in contact with a support, or corrosion-causing substance, must be protected against corrosion
- Any possible condensate should be collected using easily accessible drip legs
- Provide individual shutoff valves for each appliance (or each apartment if the piping is into a multi-tenanted buildings) at a convenient and accessible location
- All pipe outlets not in use should be suitably capped using a permanent capping system
- Allow for sufficient pipe redundancy to allow for partial shutdowns of the reticulation system as required, avoiding full shutdowns on many occasions
- NFPA 54 requires that gas pipework that is likely to become energised is to be electrically bonded

The following notes apply to underground piping:

- Underground pipework must be buried 0.8m below grade for a carriageway, or 0.3m below any pavement
- If this depth of cover cannot be maintained the pipework should be installed in a pipe sleeve or protected with shielding
- If practicable the pipework should be at least 25cm away from other utilities for ease of maintenance



Underground LPG pipework must be protected

- Both ends of the underground pipe should be provided with isolating valves
- If steel pipe is used, it should be protected against corrosion i.e., wrapped with anti-corrosion tape or fitted with cathodic protection (CP)
- Tracer wire and warning tape should be provided to indicate LPG pipes are underneath, especially for PE or Polyamide pipes


Buried PE pipe being laid

Any transition piece made of steel should be protected against corrosion. Painting alone is insufficient protection against corrosion.

Warning tape

8.6 Testing and Commissioning

Inspection and testing are to be carried out before the commissioning and operational phases and it should include all pipework from the storage tank through to the appliances.

During installation there is a possibility that foreign objects and debris might have entered the tank and pipework interior, and these must be removed.

The technician must be qualified to undertake the testing and commissioning process as it is a safety critical activity. Some general requirements are outlined in NFPA 54 (section 8.1).

Isolating valves cannot be used a as bulkhead during pressure test.


Underground LPG tanks and vapouriser room

Some general comments about testing and commissioning include:

- All LPG piping should be inspected and tested prior to being put into operation
- Prior to testing, the interior of the tank and pipework should be cleared of any foreign matter
- The test medium can be air, nitrogen, CO2, or an inert gas. Oxygen must never be used. Nitrogen and CO2 are useful, in that when LPG is introduced into the reticulation system, the formation of a flammable mixture is not possible. The Nitrogen or CO2 are easily purged
- All pipe joints should be exposed for examination during testing
- The LPG pipework can be tested as a complete unit or in sections
- Test pressure should not be less than 1.5 times the maximum working pressure
- Test duration should be maintained for not less than 30 minutes for each 14m3 (500ft3) of pipe volume (or fraction)
- Test duration is not required to exceed 24 hours
- The test pressure for Propane should be six bars minimum
- The test pressure for Butane should be three bars minimum
- Detection of leaks should be determined by a calibrated pressure measuring device and an approved gas detector or leak detection fluid
- If leak detection fluid is used it should be thoroughly rinsed off with water on completion of testing
- Any source of leak should be repaired or replaced and retested
- Record the pressure test results, date and location and retain for reference for the future
- After pressure testing, and when LPG is introduced into the system, the piping should be checked for leaks at the normal operating pressure before appliances are used

Once the system has been thoroughly inspected and tested, the installation must be immediately purged to remove any air from the system which would create an inflammable condition. To enable effective purging to take place there should be purging points designed into the system.

The process for purging the pipework should include the following:

- Any appliances and equipment that are not included in the testing should be isolated or disconnected
- Purging should be done outdoors if the pressure is over 2psig and the pipe size greater than 63mm dia.

- Pipelines should be purged after any leak test
- It is allowable to purge directly with LPG if pipelines are not more than 32mm diameter
- Purging should be done with inert gas if the pipeline is over 32mm diameter
- Never purge with Oxygen!
- All gas released during purging must dissipate, and not accumulate in confined spaces
- Purged gas should be discharged at least 3.0m away from any potential ignition sources, building openings, and 7.6m away from any mechanical air intake openings
- Purging shall be done using a burner with a continuous source of ignition and monitored with a combustible gas detector
- Purging shall be stopped once gas is detected
- Each appliance and piece of equipment should be purged before being placed into operation
- Pipelines must be purged to their extremities

It is good practice to undertake periodic inspection and maintenance with a leak test recommended every three years. Again, this should only be done by a fully trained and competent person. The process of periodic inspection and maintenance should include the following:

- Bulk LPG installations should be inspected and tested in accordance with local regulations
- Pipelines should be tested at frequencies not exceeding three years
- Conduct regular visual examinations to check for any corrosion
- Carry out leak tests on pressure pipelines
- Regulators should be inspected annually and replaced after a period not exceeding ten years
- Pressure relief valves should be replaced every five years with new or re-certified units
- If fitted, pressure gauges should be inspected annually and replaced after a period not exceeding ten years
- Meters should be inspected annually and replaced after a period not exceeding twenty years

9.0 End User Safety Awareness

End users of a reticulated LPG system may not be familiar with LPG. They may also be unfamiliar with using gas delivered through a meter for the first time. The key challenge is consumer safety. Consumers should understand the basic properties of LPG (see Appendix One).

Transitioning from traditional fuels to LPG - a totally different type of fuel which cannot be seen or touched - creates a challenge to ensure the consumer is fully aware of the issues surrounding the safe storage, handling and use of the fuel.

Consumers of LPG used for cooking in the residential sector maybe more familiar with storing and handling LPG cylinders than checking gas meters supplied from a reticulated system.

9.1 Consumer Safety

The LPG supply to the meter will be the responsibility of the marketer/distributor. The transfer of title from the marketer/distributor to the consumer takes place at the meter.

The responsibility for caring for the meter, and for ensuring they are fit for purpose, lies with the consumer and they should be provided with the necessary guidance to enable them to comply with their obligations.

Meters should always be installed in a well-ventilated position and in a location where they can be easily read. Telemetry technology now allows for the remote reading of tanks and meters. Consumers can monitor the amount of LPG being used by monitoring their meter readings. Meter readings may be available on a mobile phone app.

Metered supplies will be read and invoiced on a regular (often monthly) basis. This presents an opportunity to remind the consumer of safety messages.

Metered delivery involves no physical lifting by the consumer because LPG supply is either from a central bulk storage tank, or cylinders located outside of the property which are accessed by the supplying company.

Metered supplies also eliminate the risk of damage to the building (floors and walls) caused by handling a cylinder in the household, and personal injury by lifting cylinders.

With metered supplies, there is no need to disconnect the supply of LPG at the regulator as it is a permanent fixture. However, the consumer needs to be given clear instructions on checking for leaks. The consumer can detect leaks by listening for a 'hissing' noise or by smelling for gas. Regular testing of all joints using soapy water will show where any leaks are by the appearance of soap bubbles. These joints will be around the inlet and outlet to the meter, the connections to the regulator and appliance, and the appliance itself.

With both cylinder and metered supply there is a need for good housekeeping and for keeping everything clean and free from contamination.

Meters will be read on a regular basis (typically every month) and the consumer will be invoiced in arrears. If the meters are read manually the opportunity exists for communication between the marketer/distributor and the consumer on issues related to safety. If the meters are read remotely there may be opportunities to communicate safety messages to the consumer when the invoices are sent. Safety

instructions however must include the basic properties of LPG, and the typical parts of the reticulation system the customer is required to check.

Typical domestic LPG appliances include cook stoves, ovens, water heaters, grillers, space heaters, etc. Appliances used should be manufactured to the appropriate standards and carry their own operating and periodic maintenance instructions. Other general advice on keeping appliances clean and tidy, and inspecting for uncontrolled leaks, will form part of the safety instructions to consumers.

If in doubt the appliance manufacturer should be contacted about any specific instructions regarding safety.

One important message to consumers regarding appliances is the need to match the type of LPG being used. Propane has a higher vapour pressure than butane and must only be used for propane rated appliances.

The cookstove is the most common domestic LPG appliance and below is a general guide on operating this appliance safely:

- Always place the cookstove in a well-ventilated location with adequate air circulation to support complete combustion and disperse products of combustion safely
- To turn the burner 'ON', first ensure the supply pipe is open from the meter
- Then push the relevant knob on the appliance and turn to the 'ON' position ready to ignite the burner
- For burners without a piezo igniter, light a match first and bring lighted match near burner before turning burner knob to the 'ON' position
- To turn the burner 'OFF', turn the stove knob to the 'OFF' position to extinguish the flame then close the valve on the supply pipe
- Avoid any spillage on the stove when cooking as it can clog the burner holes
- Make sure to switch off the appropriate burner before removing the cooking pot
- Never dismantle or repair the gas valve or burner nozzle
- If the cookstove has a glass surface do not clean with a wet cloth (the glass may be hot and create a steam burn)

Point of sale material to communicate safety messages includes information leaflets that can be made available at retail outlets or handed to consumers when the meter is being read.

The messages should be clear and simple and in the appropriate language of the recipient consumer. Diagrams and cartoon characters can make the subject of emergency procedures more engaging and less fearful.

Point of sale leaflets do not need to be produced with expensive paper quality material. The local LPG industry association could be used for producing generic product safety information to reduce artwork and printing costs and this also sends out consistent messaging.

Point of sale information can also be communicated to the consumer during maintenance visits, on notice boards and at retail outlets (see Appendix Four).

The amount of information to be conveyed means the font size must be small, and this can make it difficult to read. To overcome this, the use of technology now makes it possible to utilise QR codes that can be scanned by the consumer using smart devices (see Appendix Two).

QR codes can contain much more detail as the following example from DCC Energy shows:

(https://www.dsg-energy.com/we-care/?lang=en)

The use of social media for communicating to consumers about choice and information has become a feature of the digitalisation era and is an easy, quick, and effective way to get messages across to consumers. Social media platforms such as Twitter, Facebook and LinkedIn allow soundbite messages to be conveyed in a very cost-effective manner. Many LPG suppliers create and maintain their own website, and ensure regular updates on safety, appliances, billing and Q and A sections.

The Propane Education and Research Council (PERC) in Washington DC, USA, use Twitter to carry safety messages to users of propane equipment.

An example is a video consumer safety series 'If you suspect a gas leak'. The two-minute video illustrates some of the main messages for users of propane (LPG) and small bulk tanks supplying LPG to the domestic household. (If You Suspect a Gas Leak | Propane.com)

Under the tweeted heading it explains '…everyone in your family should know what to do if they smell propane (LPG). Here are a few steps to take in the event of a potential gas leak…'. The video highlights some of these steps.

Social media reaches a wide audience and can include the use of videos like this one. It is also a powerful tool to send out soundbites in a reactive or planned manner.

The introduction of digitalisation, and the use of smart devices with cameras, has allowed individuals to not only watch videos on smart devices but also produce videos. The ability to use video material to communicate to consumers is a powerful tool because smart devices have penetrated deeply into the global consumer market, even into households with limited disposable incomes.

The subject of safety is important and the option of presenting safety information to consumers in an appealing manner increases the chances of it being seen and understood.

Previously the cost of producing videos was prohibitive, especially for safety messages which had no tangible ROI. Today, simple videos can be produced with a very low budget to illustrate messages that might otherwise be difficult to get across in words and pictures.

The WLPGA has produced a simple five-minute video focusing on LPG properties that affect the safe storage and handling of LPG (https://www.youtube.com/watch?v=9X6EG3g8JHU). The video is designed to be used by all personnel in the distribution channel and is particularly suitable for consumers as it describes how LPG behaves in a domestic installation environment (see also Appendix One)

The messages are clear and simple and have been presented in a schematic style. The voiceover and subtitles are in English, but they could be easily changed to any language.

There are many other videos available but this one has been produced by the WLPGA, with input from its members, and is recommended for all stakeholders, including the consumer, in the LPG distribution channel.

Cadent Gas Limited (UK) owns and manages four of the eight gas distribution networks in the UK: West Midlands, North-West England, East of England, North London, supplying gas to around 11 million homes.

They have produced two short videos explaining what to do, and not to do, if there is a gas leak in the home. (https://youtu.be/la3PWO5zthY) and (https://youtu.be/x3JamSaLAgY), for people with hearing disabilities.

There will be opportunities, at the time the meter is being read, for distributor personnel reading the meter, to convey information about the safe use of LPG. This might include how to check the equipment for leaks and what to do in an emergency.

The opportunity for face-to-face dialogue with consumers is important and one that should be seized. In areas where LPG is being introduced for the first time the use of demonstrations is one of the best ways of communicating to consumers who previously have relied on traditional fuels which are more predictable in nature.

9.2 Emergency Response

Consumers must be aware of the basic steps to take in case of an LPG emergency. This will help avoid injuries and prevent escalation of a minor incident into a serious emergency which may have tragic consequences. Basic actions to take in case of a leak or suspected leak:

- Extinguish immediately all naked flames, do not smoke, strike matches or do anything which could cause ignition
- Turn off the gas supply by closing the valve by the meter - by turning it 90 degrees
- Open all doors and windows carefully to ventilate the property
- Do not use any electrical appliances or turn on/off any electrical switches
- If the gas leak is in a cellar or basement, do not enter and instead evacuate the building
- If there are any electrical security entry phones/locks, open doors manually
- If safe to do so, switch off all mains power at the electrical distribution board

A pungent odourant is added to LPG to identify leaks. The smell of gas within a property can be alarming and should be treated seriously. There are several important things that need to be done if gas is present.

Immediately phone the local emergency services using the contact telephone number at any time of the day or night.

Sometimes a gas leak can lead to physical symptoms such as dizziness, fatigue, nausea, and headaches. These symptoms should ease when the customer gets into fresh air but if the symptoms continue, they should visit their doctor as a precaution.

If the consumer has these symptoms but cannot smell any gas, it could be a sign of a carbon monoxide leaks and poisoning. Appendix Three has more information about carbon monoxide leaks.

Always wait until a qualified gas engineer has given the all-clear before returning inside the property.

APPENDIX ONE

LPG PROPERTIES, CHARACTERISTICS AND HAZARDS

Liquefied Petroleum Gas (LPG) - Comprises commercial propane and commercial butane, and mixtures thereof. They are hydrocarbon gases that can be changed into a liquid and changed back into a gas by the simple application and release of pressure at about ambient temperature

Density – LPG vapour is heavier than air and tends to gather at low areas such as drains, pits, cellars and other depressions. As a colourless liquid, LPG occupies around 0.4% of its vapour volume, but is about half the density of water and will readily float on water without mixing, before vapourising

Cooling effect – LPG liquid vapourises and cools rapidly; it can therefore inflict severe cold burns if it comes in contact with bare skin.

Non-toxic – LPG is not toxic. However, it has an anaesthetic effect when mixed in high concentrations with air. The greater the concentration (i.e,. as available Oxygen declines), the greater the risk of asphyxiation.

Smell - What people know and recognise as the 'LPG smell' is usually added to LPG before distribution. This smell can be detected if the LPG content of air is as little as 0.4% (or just 20% of the lower limit of flammability). However, odour is not the only means of detection. Large leaks will also be obvious through hissing or condensation or frosting around the leak; small leaks will show up as bubbles if detergent mixed with water is applied to the suspected leak area. **NEVER try to detect leaks with a naked flame or other kinds of ignition. Always rinse pipework and fittings with fresh water after leak testing.**

Flammability – LPG can ignite when it forms between 2% and 10% of a vapour/air mixture, so the risks associated with poor handling, storage or usage should be obvious. Uncontrolled ignition of LPG can cause serious fires or explosions (i.e. if ignited within a confined space). A fire started some distance from an LPG leak can very quickly travel back to the source of the leak itself. An LPG cylinder involved in a fire may overheat and rupture violently. The power and intensity of an LPG fire or explosion should never be underestimated.

Liquid Expansion – LPG liquid has a high coefficient of expansion. Tanks, cylinders, pipelines and equipment must be protected against the high pressure resulting from liquid expansion with even small temperature rises.

The following table shows some typical physical properties and characteristics of LPG.

TABLE OF TYPICAL CHARACTERISTICS FOR LPG

Typical Characteristics of Propane and Butane **PHYSICAL PROPERTY**		**COMMERCIAL PROPANE**	**COMMERCIAL BUTANE**
Litres/tonne of liquid at 15^{O}C Litres/ton of liquid Litres/kg of liquid US barrels/tonne		1,965 – 2,019 1,996 – 2,051 1.96 - 2.02 12.4 – 12.7	1,723 – 1,760 1,750 - 1788 1.72 - 1.76 10.8 – 11.1
Relative density (to water) of liquid at 15^{O}C		0.50 - 0.51	0.57 - 0.58
Ratio of gas to liquid volume at 15^{O}C and 1015.9 mbar		274	233
Relative density (to air) of vapour at 15^{O}C and 1013.25 mbar		1.40 - 1.55	1.90 - 2.10
Volumes of gas/air mixture at lower limit of flammability from 1 volume of liquid at 15^{O}C and 1015.9 mbar		12,450	12,900
Boiling point ^{O}C		Minus 45	Minus 2
Vapour pressure at 0^{O}C	barg	4.5	0.9
Vapour pressure at 15^{O}C	barg	6.9	1.93
Vapour pressure at 38^{O}C	barg	14.5	4.83
Vapour pressure at 45^{O}C	barg	17.6	5.86
Upper limit of flammability,	% v/v	10.0	9.0
Lower limit of flammability,	% v/v	2.2	1.8
Gross calorific value	MJ/m^3 dry	93.1	121.8
	BTU/ft^3 dry	2,500	3,270
	MJ/kg	50.0	49.3
	BTU/lb	21 500	21 200
Net calorific value	MJ/m^3 dry	86.1	112.9
	BTUu/ft^3 dry	2,310	3,030
	MJ/kg	46.3	45.8
	BTU/lb	19,900	19,700
Latent heat of vapourisation Latent heat of vapourisation	kJ/kg at 15 °C BTU/lb at 60 °F	358.2 154	372.7 160

APPENDIX TWO

EXAMPLE OF SAFETY INFORMATION USING A QR CODE

QR codes on a safety tag contain a great deal more information than could be illustrated on the tag itself.

https://www.dsg-energy.com/we-care/?lang=en

The use of QR tags to disseminate safety information should always be checked with the local authorities. This example has been provided by DSG Energy (DCC).

'…Safety is a core value for DSG Energy. We maintain appropriate safety management systems reflecting the nature and complexity of the risks in the business. Safety leadership and employee engagement are key focus areas to promote positive behaviours such as intervening when a situation is unsafe, recognising positive safety standards and more importantly, educating our customers to use our product in a safe manner. We promise to work to continuously improve performance through risk assessment, procedural and engineering controls, training, learning from events and safety culture promotion to our customers…'

Connecting Safely

- Always use a hose designed for use with LPG. The hose should have a maximum length of 2m with connecting clamps at both ends. Hoses should be checked frequently and replaced every three years or as indicated on the hose since they deteriorate over time
- The metered gas supply must be equipped with pressure regulators designed specifically for either propane or butane, which will regulate the pressure when temperatures change. Use the correct regulator for the type of gas
- Never smoke while connecting the equipment and do not check for leaks with a flame

Using LPG Safely

- Regularly check your hose for signs of damage or cracking
- When the appliance is not in use, turn off the valve or regulator tap
- Do not let children handle the meter or appliances
- Arrange safety checking and maintenance of your LPG appliances and installation every 18 months.

APPENDIX THREE

CARBON MONOXIDE

Carbon monoxide poisoning is deadly. Carbon monoxide is produced by the incomplete burning of many fossil fuels. There are several ways that this can occur, including poorly fitted or badly maintained LPG appliances, inadequate or disrupted ventilation, and blocked chimneys or vents.

There are several types of gas appliances that can create carbon monoxide, these include:

- Gas cookers
- Free-standing gas heaters
- Gas fires
- Boilers and water heaters

Carbon monoxide can also be produced as a by-product of burning solid fuels such as coal, charcoal, wood or kerosene:

- A lit fire with a blocked flue or chimney will prevent carbon monoxide from escaping and produce it into your home
- Using a gas appliance in a confined space without proper ventilation, or bringing it inside a caravan or tent after use, can result in dangerous levels of carbon monoxide being produced
- Appliances designed for outdoor use must not be used inside a building

To minimise the risks of carbon monoxide poisoning:

- Ensure that all gas appliances are properly installed and regularly serviced on an annual basis. This work should be carried out by a registered gas installer
- Ensure that all chimneys and flues are regularly cleaned to prevent blockages, this should also be done annually
- Allow adequate ventilation into the room where the gas appliance is located to ensure there is plenty of oxygen available for complete combustion, carbon monoxide is easily generated where there is inadequate Oxygen
- Fit carbon monoxide alarms and test them regularly. Alarms should be fitted around three metres from an appliance at door height. This would ideally be in each room where a gas appliance is fitted

If there is any concern about the possibility of carbon monoxide poisoning, you should act very quickly and:

- Open all doors and windows

- Move outside into fresh air
- Call the local Gas Emergency Services
- Stop others entering the building until the-all clear is given

Carbon monoxide has no smell at all, making it very difficult to detect a leak. Further to that, you cannot taste or see the gas either - this is part of the reason it is known as 'The Silent Killer'.

Having a working audible carbon monoxide alarm and learning to spot the physical signs and symptoms of carbon monoxide poisoning, is essential to minimise the health risks posed by a leak.

If you spot any of the signs below, it does not mean that there is a release of carbon monoxide, but it is possible:

- Gas flame appears 'floppy' and burns orange or yellow rather than mostly blue
- Pilot light frequently blows out
- There is soot or yellow-brown staining on or around an appliance
- You see or smell smoke or have excessive condensation (water drops or fog) in the room where you have a gas appliance

After you have inhaled carbon monoxide, it enters your bloodstream and begins to mix with the haemoglobin. This creates carboxyhaemoglobin, with a level of 30% of carboxyhaemoglobin indicating severe exposure. This process makes it impossible for your blood to carry oxygen around the body, leading to illness, tissue and cell failure and, from long term exposure, potential paralysis, brain damage and death.

There are several symptoms caused by carbon monoxide poisoning including:

- Headache
- Dizziness
- Breathlessness
- Nausea or feeling sick
- Collapse
- Loss of consciousness

If you are experiencing any of these symptoms and they cannot be explained by any other reason, such as another illness you are already aware of, or you immediately feel better when leaving the property, there's a chance you have been or are being exposed to carbon monoxide.

Some people often describe the early symptoms of exposure as being flu-like. If you have experienced these early symptoms or know you've been exposed to low levels of carbon monoxide, you should seek medical advice from your doctor.

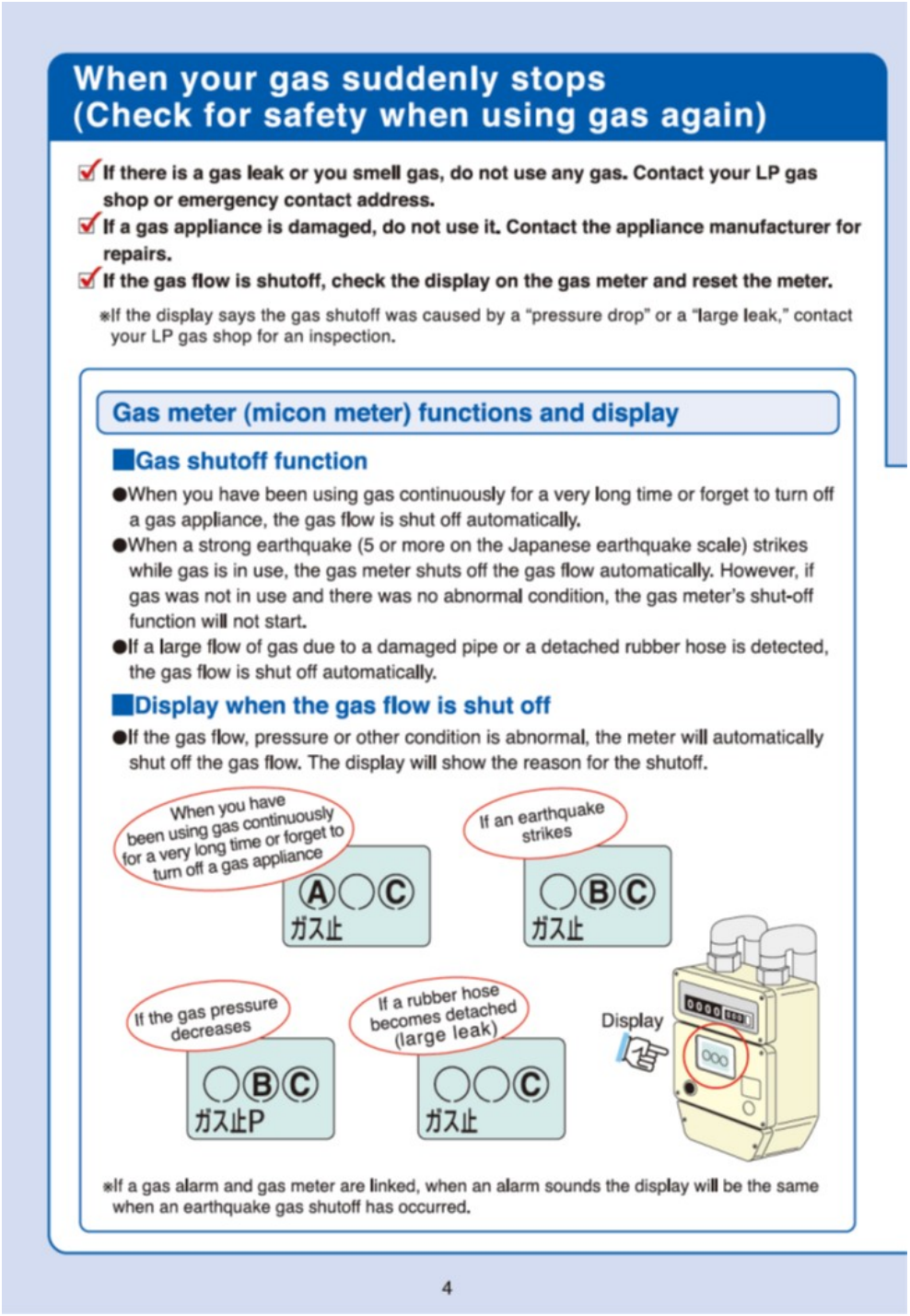
The effects of carbon monoxide exposure get worse over time, meaning early detection is vital. Over an extended period of carbon monoxide exposure, some of the following symptoms may occur:

- Vision and memory loss
- Confusion and difficulty thinking
- Changes in mood
- Chest pain, heart stress, unconsciousness, and death

Some of these symptoms will only come from inhaling high levels of carbon monoxide but can have potentially fatal results. It is also important to remember that these symptoms could also happen in the first instance, so immediate medical help should be sought if you begin to experience these symptoms.

APPENDIX FOUR

EXAMPLE OF SAFETY LEAFLET FOR A METERED SUPPLY



When your gas suddenly stops (Check for safety when using gas again)

- ☑ **If there is a gas leak or you smell gas, do not use any gas. Contact your LP gas shop or emergency contact address.**
- ☑ **If a gas appliance is damaged, do not use it. Contact the appliance manufacturer for repairs.**
- ☑ **If the gas flow is shutoff, check the display on the gas meter and reset the meter.**

※If the display says the gas shutoff was caused by a "pressure drop" or a "large leak," contact your LP gas shop for an inspection.

Gas meter (micon meter) functions and display

■Gas shutoff function

- ●When you have been using gas continuously for a very long time or forget to turn off a gas appliance, the gas flow is shut off automatically.
- ●When a strong earthquake (5 or more on the Japanese earthquake scale) strikes while gas is in use, the gas meter shuts off the gas flow automatically. However, if gas was not in use and there was no abnormal condition, the gas meter's shut-off function will not start.
- ●If a large flow of gas due to a damaged pipe or a detached rubber hose is detected, the gas flow is shut off automatically.

■Display when the gas flow is shut off

- ●If the gas flow, pressure or other condition is abnormal, the meter will automatically shut off the gas flow. The display will show the reason for the shutoff.

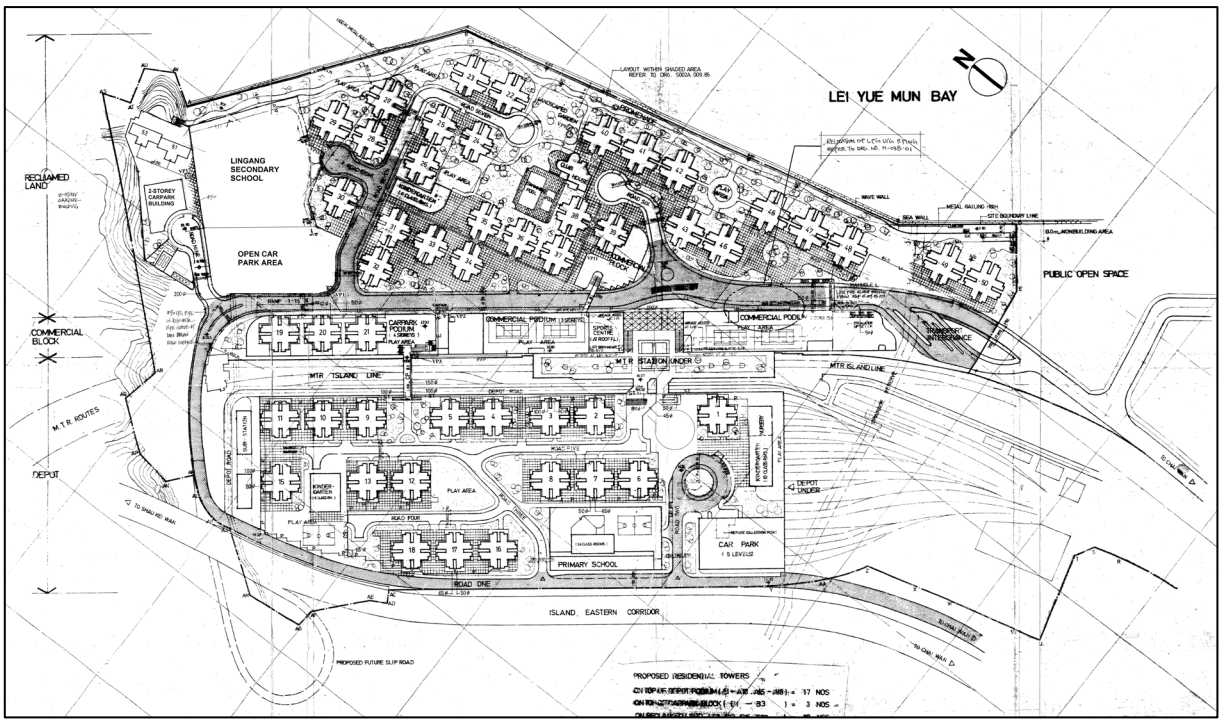
※If a gas alarm and gas meter are linked, when an alarm sounds the display will be the same when an earthquake gas shutoff has occurred.

4

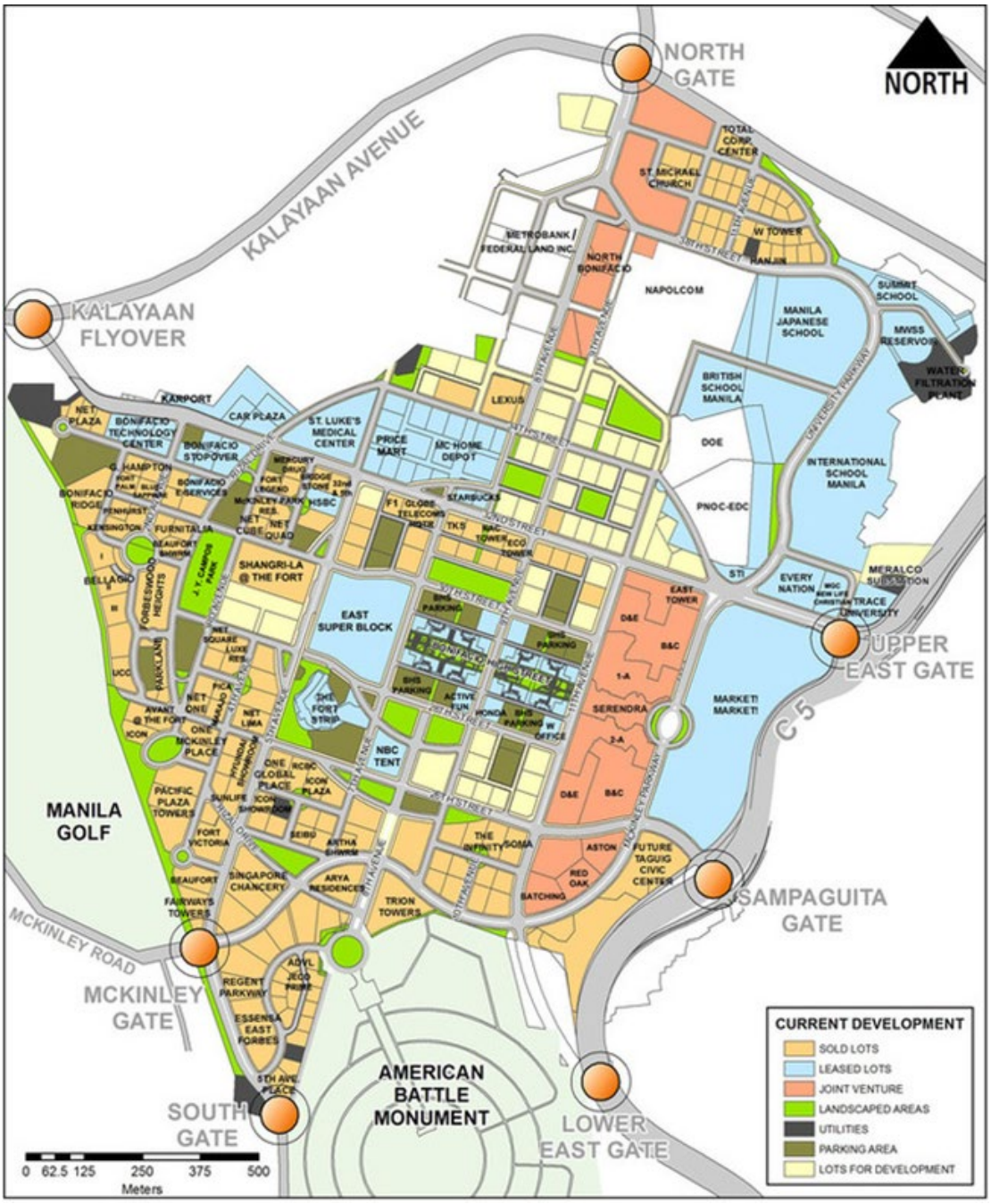
Example of a safety leaflet for a piped LPG supply - courtesy DCC (Hong Kong)

APPENDIX FIVE

EXAMPLES OF A LARGE LPG RETICULATED RESIDENTIAL PROJECT



Large, reticulated LPG project in Hong Kong with 48 residential multistorey buildings, school, restaurants and shopping centre



Layout plan of a large LPG reticulated project in the Philippines spread over 240 hectares

REFERENCES

WLPGA – Guidelines for Good Safety Practices in the LPG Industry

WLPGA – Guidelines for Good Business Practices in the LPG Industry

NFPA54 & 58

DISCLAIMER

While the WLPGA has made efforts in good faith to ensure that the information and advice contained in this Guide is accurate, WLPGA offers no implied warranty of merchantability or fitness for any particular purpose, nor accepts any responsibility whatsoever for any damages arising from the use of the information contained in this Guide.

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